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(71) Applicant (for all designated States except US): IMI CORNELIUS (UK) LIMITED [GB/GB]; Tything Road, Alcester, Warwickshire B49 6EU (GB).

(72) Inventor; and

(75) Inventor/Applicant (for US only): COOK, Christopher, Michael [GB/GB]; 26 Mercot Close, Oakenshaw South, Redditch, Worcestershire B98 7YX (GB).

(74) Agents: SYKES, John, C. et al.; IMI plc, Patents & Licensing Dept., P.O. Box 216, Birmingham B6 7BA (GB).

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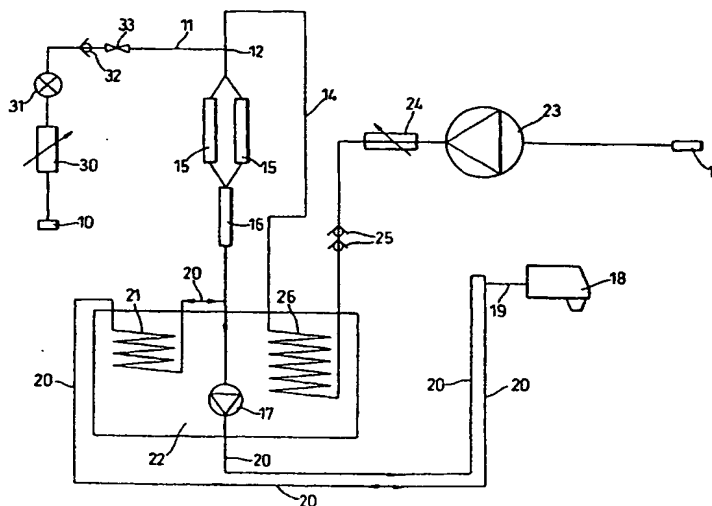
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(54) Title: CARBONATION



(57) Abstract

The apparatus for the carbonation of a liquid comprises a source (10, 40, 60) of pressurised carbon dioxide gas, a fitting (12, 41, 61) having a first inlet for connection to the carbon dioxide source (10, 40, 60) and a second inlet connectable to a source (13, 42, 62) of the liquid, a control device (30, 31) for permitting or stopping flow of carbon dioxide gas from the source (10, 40, 60) thereof into the fitting (12, 41, 61) and means to carbonate the liquid with the carbon dioxide gas, characterised in that the carbonation means is provided in two stages, the first stage comprising a turbulating device (15, 49, 50, 66) having an inlet end connected to the outlet of the fitting and having an outlet end connected to the second stage, which second stage comprises means (17, 51, 67) to further break up and dissolve remaining carbon dioxide bubbles in the liquid.

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CARBONATION

This invention relates to the carbonation of liquids. It is particularly concerned with the carbonation of beverages including plain water and is specifically designed to provide a means of carbonating
5 beverages in an as required, on demand basis.

There have been many prior proposals to provide means of combining carbon dioxide with water and previous "on demand" systems have had the objects of reducing the size of or eliminating the traditional carbonating tank, and providing a volume of carbonated water that is not
10 limited by the size of the tank nor the system's ability to replenish the supply produced therein. Some on demand systems utilise the strategy of increasing the surface area of contact between the carbon dioxide gas and the water. However, many such systems, while effective in large bottling facilities, do not translate well to the far smaller size constraints of
15 fountain beverage dispensing machines. Other carbonating strategies which utilise specialised structural geometry for combining water and carbon dioxide or microporous materials to enhance the mixing and/or area of contact therebetween are also known. However, these approaches, while meeting the size constraints of small fountain systems,
20 have not found any real success or acceptance in the market place, as the level of carbonation provided thereby is generally too low for commercial purposes.

Accordingly objects of the present invention are to provide a means of carbonating that consistently provides a desired level of
25 carbonation on demand, to provide a means that meets the size

constraints of fountain beverage systems and to provide a means which can be used equally with either post-mix or pre-mix dispensers.

Accordingly the invention provides in one aspect an apparatus for introducing carbon dioxide gas into a liquid, the apparatus comprising a source of pressurised carbon dioxide gas, a fitting having a first inlet for connection to the carbon dioxide source and a second inlet connectable to a source of the liquid, a control device for permitting or stopping flow of carbon dioxide gas from the source thereof into the fitting, and means to carbonate the liquid with the carbon dioxide gas, the means being connected to an outlet of the fitting and also being connected to a dispensing valve for carbonated liquid, wherein the carbonation means is provided in two stages, the first stage comprising a turbulating device having an inlet end connected to the outlet of the fitting and having an outlet end connected to the second stage, which second stage comprises means to further break up and dissolve remaining carbon dioxide bubbles into the liquid.

In another aspect the invention provides a method of carbonating a liquid on demand at a dispense valve, in which, when the dispense valve is opened, carbon dioxide under pressure is mixed with the liquid which is also supplied under pressure, and the mixture is passed through means to carbonate the liquid and is then dispensed at the open dispense valve, wherein the mixed gas and liquid are in a first carbonation stage passed through a turbulating device to increase the absorption of the carbon dioxide into the liquid then in a second stage are passed through means to further increase the absorption of carbon dioxide.

The apparatus may include a fluid flow restrictor connected between the source of carbon dioxide and the fluid fitting

The apparatus may also include a pump to pump the liquid from the source thereof to the fitting. Alternatively, if the liquid is water supplied under mains pressure, a pump for the liquid may not be needed unless it is desired to supply the water at pressure above mains pressure
5 or to boost the water flow.

The outlet of the turbulating device may be connected to the dispensing valve via a heat exchange cooling coil of a beverage dispensing machine.

The fluid flow restrictor, where used, may be, e.g., a small orifice
10 or a needle valve, connected to a solenoid valve. The solenoid valve may be controlled by a flow sensor which may conveniently be positioned downstream of the turbulating device. The flow sensor may also control the liquid supply conveniently via a pressure regulator and one or more non-return valves. Similarly the carbon dioxide may
15 conveniently pass through a pressure regulator and one-way valve between its pressurised source and the fluid fitting.

Thus as indicated above, the carbonation is carried out in a two stage process. The first stage of the process comprises essentially the steps described above up to and including passing the carbon dioxide and
20 the water through the turbulating device. In the second stage the fluid emerging from the turbulating device is passed to the dispensing valve via a pump or impeller whose action is to break up any remaining unabsorbed carbon dioxide bubbles in the liquid into a smaller, more easily absorbed size, thereby giving a more complete absorption and
25 dissolution of the carbon dioxide into the liquid than might otherwise be achieved by the first stage alone.

Where a pump is used in the second stage it may be a centrifugal pump but a rotating disc type, an impeller or reciprocating agitator may also be found useful. The skilled man will readily be able to choose a suitable pump or other means and housing means therefor for his particular requirements and to ensure that the desired further bubble fragmentation and hence absorption is achieved.

Preferably the second stage means, e.g. pump, should not induce heat into the fluids being pumped and should not provide a significant pressure drop in the system. In a particularly preferred embodiment the pump should result in little or no pressure drop. A centrifugal pump is particularly useful in this respect and a magnetically driven centrifugal pump is preferred although mechanically driven, e.g. chain or cooled shaft, drives may be employed. A remote drive pump has the added advantage that the internal pump parts may all be of food grade materials.

In another embodiment of the present invention, all of the components may be the same as above described, except that the pump to supply the liquid to the fitting is connected to a bag-in-box container having therein a volume of pre-mix beverage. The pre-mix beverage is specialised in that it has been produced at the bottling facility without carbonation, i.e., flat water and syrup have been combined in the desired ratio. Lacking carbonation, it can be held in a bag-in-box container. Then, by use with the system of the present invention, this specialised pre-mix is carbonated in the manner as described above. Thus, the pre-mix beverage is combined only with an amount of carbon dioxide gas that will provide for the desired level of carbonation thereof, assuming full absorption thereof. In this manner, an over-carbonating situation is

eliminated as there is no excess of carbon dioxide gas present. In addition, a much less expensive bag-in-box system can be used to replace the traditional metal pre-mix tanks.

The turbulating device may be one of a wide variety of structures that by their presence in a line through which a mixture of fluids is flowing causes the fluids to be agitated and mixed as the mixture flows into and collides with the various surfaces of the device. They are well known *per se* and may for example conveniently comprise a plastics moulding of generally longitudinal form with the desired mixing surfaces spaced along the longitudinal axis.

The invention will now be further described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic representation of a first apparatus of the invention;

Figure 2 is a diagrammatic representation of a second apparatus of the invention;

Figure 3 is a diagrammatic representation of a third apparatus of the invention;

Figure 4 is a part longitudinal sectional view of one form of turbulating device that can be used in the invention;

Figure 5 is an enlarged view of a portion of the device of Figure 4;

Figure 6 is a section on line A-A of Figure 4;

Figure 7 is a section on line B-B of Figure 4; and

Figure 8 is a section through a typical flow restrictor for the carbon dioxide.

In Figure 1 a pressurised source 10 of carbon dioxide is provided in line 11 to a T-junction fitting 12 to which a mains water supply 13 is also provided in line 14.

From the T-junction the mixture of carbon dioxide and water is
5 supplied to a pair of turbulators 15 in parallel. From the turbulators, the resulting mixed fluid is passed via a flow sensor 16 to a centrifugal pump 17 and thence to a dispense valve at a dispense head 18. The fluid reaches head 18 via a branch 19 of a continuous loop 20 around which the carbonated water flows. Loop 20 passes the carbonated water
10 through conventional python cooling coils 21 in a conventional cooling unit 22.

Water from source 13 passes through valve (and an optional pump) 23 if pressure above mains pressure or if a boost to pressure is required as determined by flow sensor 16. The water then passes
15 through a pressure regulator 24 and via two non-return valves 25 into cooling coils 26 in cooler 22. It may be pre-cooled here to, for example, under 4°C. The cooled water then passes along line 14 to be mixed with the carbon dioxide at junction 12.

From its source 10, the carbon dioxide passes through a pressure
20 regulator 30 then through a solenoid valve 31 whose opening and closing is also controlled by flow sensor 16. From solenoid valve 31, the carbon dioxide flows via a one-way valve 32 to a flow restrictor 33 and thence to the junction 12 to mix with the water.

The dispense head 18 may contain one or more dispense valves.

25 This arrangement is particularly suitable for multi-valve dispense.

On opening a dispense valve at head 18, carbonated water passes through the valve and the flow sensor 16 operates valve 23 and 31 to

admit more water and carbon dioxide respectively. When the dispense valve is closed, the flow sensor accordingly closes valves 23 and 31. Thus the flow sensor only allows carbon dioxide to pass into the system when water is flowing into the turbulators so that passage of gas alone is prevented. With the dispense valve closed, the carbonated water can be recirculated around line 20, thereby maintaining it in its cooled condition and maintaining the gas dissolved in the water. As there is no check valve between lines 14 and 20, flow may take place along both sides of the circuit in high draw off situations.

By way of example only, the carbon dioxide may be supplied at 60 p.s.i. (about 4 bar) and the water at the same pressure. The static pressure in line 14 may be about 70 p.s.i. falling to about 63 p.s.i. at 35 ml/sec water flow and to about 58 p.s.i. at 70 ml/sec water flow. The gas flow may be about 1.5 l/min at 35 ml/sec water flow and 3.0 l/min at 70 ml/sec water flow.

The carbonated water dispensed at head 18 may be at about 2°C.

Thus as carbonated water leaves the apparatus via a dispense valve, more gas and water are caused to enter in a controlled manner. The desired proportions of the two fluids can be accurately maintained to provide the required degree of carbonation.

The degree of carbonation, i.e. actual absorption of the carbon dioxide gas into the water, as the mixed fluid leaves the turbulators may be some way short of 100 per cent, e.g. from 80 per cent upwards. The mixed fluid is then subjected to the action of the pump 17 and the bubble fragmentation it produces and this, together with time (from recirculation) and further cooling, can successfully lead to virtually 100

per cent carbonation. A desirable level of carbonation can, therefore, be readily achieved.

In Figure 2 is shown an alternative carbonation system in which the first and second stages of carbonation take place at different pressures and in which the water inlet flow rate and carbonated water outlet flow rate are each fixed and gas is allowed to enter the system precisely to fill any empty volumes caused by the difference in outflow and inflow water rates.

A pressurised source of carbon dioxide is supplied from a source 40 to a junction 41 with a water supply line 42. The water is supplied by a pump 43 from a source (not shown) and via a flow regulator 44 and two non-return valves 45 and then a flow sensor 46 through the coils 48 of a cooler 47 where it may be pre-cooled to a similar degree as described with reference to Figure 1. As shown, the non-return valves 45 and 46 and the flow sensor are positioned in the cooler 47 although it will be appreciated that this is not essential.

From the cooler 47 the water flows in line 42 to the junction 41 where it mixes with the carbon dioxide as they both are then passed through one or more turbulators, two turbulators 49 and 50 being shown here aligned in parallel.

From the turbulators, the mixed fluids, i.e. partially carbonated water, are passed via a centrifugal pump 51 which causes further absorption of carbon dioxide by fragmenting the remaining bubbles as explained above. The carbonated water then enters cooler 47 where it passes through cooling coils 52 and from there to dispense head 53 of a dispenser 54 and then around a recirculation loop 56 .

One way valve 55 between the water supply line 42 and recirculation loop 56 prevents uncarbonated water flow into the carbonated water supply line.

When a carbonated drink is dispensed at head 53 water flow into
5 the system occurs at a fixed rate, e.g. 1 oz/sec, with an outlet flow rate at the dispense head of, e.g. 1.25 oz/sec. Carbon dioxide gas, therefore, also enters the system from its pressurised source, its pressure being higher than the water pressure .

After dispense has finished, the water pump 43, actuated by flow
10 sensor 46 will continue to run until all the gas bubbles in the system have been dissolved, i.e. the pump trickles water in via non-return valve 55 until all the gas is dissolved. The pressure will then rise to a pre-set level e.g. 7.5 bar, and the water flow is switched off.

After the water flow is switched off, pump 51 continues to operate
15 and recirculates the carbonated water. The second stage carbonation occurs during a short period of, say, 10 to 15 seconds after dispense has finished and the pump 51 recirculates the carbonated water around line 56 causing the system to adjust naturally to its equilibrium pressure of, say, 4 bar. Thus a 10 to 15 second interval is required between dispensed
20 drinks.

It will be appreciated that the carbonated water recirculation loop must contain sufficient volume for a single dispense.

A third arrangement of the invention is shown in Figure 3.

Carbon dioxide from a pressurised source 60 (e.g. at 105 p.s.i.) is
25 supplied to a T-junction 61 where it is mixed with liquid from a source 62. The liquid is pumped to the junction 61 by pump 63 via a flow

regulator 64 at e.g. 120 p.s.i. and then through a cooler 65. The gas flow may be, e.g., 1.0 l/min and the liquid flow, e.g. 1.9 l/min.

From junction 61 the mixed fluids are passed at about 100 p.s.i. through a pair of parallel turbulators 66 where the first stage carbonation
5 takes place.

From the turbulators 66, the partially carbonated liquid flows at, e.g. 90 p.s.i., via a sheer disc or low pressure centrifugal pump 67 to give the second stage of carbonation. On dispensing a drink via dispense valve 68 the carbonated liquid is passed through a further cooler 69 so
10 that it is dispensed into glass 70 at the appropriate temperature.

Thus this third system does not have a recirculation line.

In Figures 4 to 7 is shown one form of turbulator for use in the present invention. It comprises a longitudinally extending plastics moulding in the form of a tube 130 having a plurality of internal
15 angularly positioned surfaces 134a alternating with protrusions 134b spaced along its length, the surfaces and protrusions extending generally transversely from the axial length of the turbulator. These surfaces and protrusions agitate the water and carbon dioxide as they flow through the tube to cause a random turbulence flow as opposed to a more uniform
20 laminar flow.

The surfaces and protrusions within the turbulator tube need not be formed as separate structures from the tube. For example, the tube can be formed to have a plurality of surface indentations that intrude into the internal volume of the tube to cause the desired agitation. Alternatively
25 the turbulence means may be a separate axially-extending length within the tube of, e.g. generally spiral configuration. The spiral configuration may, for example, comprise two separate spiral configurations consisting

of alternating segments of a first spiral and a second spiral whereby flow through the tube is continually interrupted and divided.

The pressure drop across the turbulating device may be so large that undesirable carbon dioxide "break out" from solution may occur. It is, therefore, preferable to use two or more turbulators in parallel rather than a single larger turbulator. Where a plurality of turbulators is used, they need not be of the same diameter. The skilled man will readily be able to devise the best arrangement for his particular requirements.

In Figure 8 is shown one form of flow restrictor suitable for use in the invention. This is a tube 121 in gas flow line 115. Tube 121 has opposed attachment ends 121a, a reduced diameter interior portion 121b and a tube abutment disc 121c. As is well known in the art, restrictor tubes can be obtained having a wide variety of internal diameters. Moreover, various types of flow restrictors are known in addition to tubes, e.g. cap tubes, flow washers, and needle valves.

CLAIMS

1. An apparatus for introducing carbon dioxide gas into a liquid, the apparatus comprising a source (10, 40, 60) of pressurised carbon dioxide gas, a fitting (12, 41, 61) having a first inlet for connection to the carbon dioxide source (10, 40, 60) and a second inlet connectable to a source (13, 42, 62) of the liquid, a control device (30, 31) for permitting or stopping flow of carbon dioxide gas from the source (10, 40, 60) thereof into the fitting (12, 41, 61) and means to carbonate the liquid with the carbon dioxide gas, the means being connected to an outlet of the fitting (12, 41, 61) and also being connected to a dispensing valve (18, 53, 68) for carbonated liquid, characterised in that the carbonation means is provided in two stages, the first stage comprising a turbulating device (15, 49, 50, 66) having an inlet end connected to the outlet of the fitting and having an outlet end connected to the second stage, which second stage comprises means (17, 51, 67) to further break up and dissolve remaining carbon dioxide bubbles in the liquid.
2. An apparatus according to Claim 1, characterised in that it includes a flow restrictor (33, 121) between the source of carbon dioxide (10, 40, 60) and the fluid fitting (12, 41, 61).
3. An apparatus according to Claim 2, characterised in that the flow restrictor (121) is a small orifice (121b) or a needle valve and is connected to a flow valve (31).
4. An apparatus according to Claim 3, characterised in that the flow valve (31) is controlled by a flow sensor (16) downstream of the turbulating device (15).

5. An apparatus according to Claim 4, characterised in that the flow sensor (16) also controls the liquid supply via a pressure regulator (24) and one or more non-return valves (25).
6. An apparatus according to any preceding claim, characterised in that it includes a pump (23, 43, 63) to pump the liquid from the source (13, 42, 62) thereof to the fitting (12, 41, 61).
7. An apparatus according to any preceding claim, characterised in that the outlet of the turbulating device (49, 50, 66) is connected to a heat exchange coil (52, 69) of a beverage dispensing machine.
- 10 8. An apparatus according to any preceding claim, characterised in that the carbon dioxide passes through a pressure regulator (30) and a one way valve (32) between its source (10) and the fitting (12).
9. An apparatus according to any preceding claim, characterised in that the second stage carbonation means is a centrifugal pump (17, 51, 15 67), an impeller, a rotating disc or a reciprocating agitator.
10. An apparatus according to Claim 9, characterised in that the pump (17, 51, 67) is magnetically driven.
11. An apparatus according to any one of Claims 6 to 10, characterised in that the pump to supply the liquid to the fitting is 20 connected to a source of the liquid in a bag-in-box container, the liquid being a pre-mix beverage.
12. An apparatus according to any preceding claim, characterised in that the turbulating device (130) is a plastics moulding of longitudinal form with mixing surfaces (134a) spaced along its length.
- 25 13. An apparatus according to Claim 12, characterised in that the mixing surfaces (134a) are angled with respect to the longitudinal axis of

the device (130) and alternate with protrusions (134b) extending transversely with respect to that axis.

14. An apparatus according to any one of Claims 1 to 12, characterised in that the mixing surfaces are formed of an axially-
5 extending length of spiral configuration within the tube.

15. An apparatus according to Claim 14, characterised in that the spiral configuration comprises two separate spirals to provide alternating segments of a first spiral and a second spiral.

16. An apparatus according to any preceding claim, characterised in
10 that it comprises two or more turbulators (15, 66) connected in parallel.

17. An apparatus according to any preceding claim, characterised in that the carbonated liquid reaches the dispense valve (18, 53) via a branch line (19) off a continuous loop (20) around which the carbonated liquid flows.

15 18. An apparatus according to any preceding claim, characterised in that the liquid passes through a cooler (22, 47) before passing to the fitting (12, 41).

19. An apparatus according to any one of Claims 4 to 18, characterised in that the flow sensor (16) only allows carbon dioxide to
20 pass through the flow valve (31) when water is flowing into the turbulating device (15).

20. An apparatus according to any one of Claims 1 to 18, characterised in that the first and second stages of carbonation take place at different pressures and the liquid inflow rate is fixed at a lower rate
25 than the carbonated liquid dispense rate at the dispense valve (53) whereby carbon dioxide is permitted to flow in from its source (40) as required during a dispense.

21. An apparatus according to Claim 20, characterised in that the carbonated liquid passes around a continuous loop (56), a non-return valve (55) allows uncarbonated liquid to pass into the loop (56) and a flow sensor (46) for the uncarbonated liquid actuates a liquid pump (43) to trickle liquid into the loop (56) after a dispense has finished to dissolve all carbon dioxide gas admitted, the pump (43) being switched off when a predetermined pressure is reached.
22. An apparatus according to Claim 20 or 21, characterised in that the second stage pump (51) is controlled to continue to operate for a period after a dispense has finished.
23. A method of carbonating a liquid on demand at a dispense valve (18, 53, 68), in which when the dispense valve is opened carbon dioxide under pressure is mixed with the liquid which is also supplied under pressure and the mixture is passed through means to carbonate the liquid and is then dispensed at the open dispense valve, wherein the mixed gas and liquid are in a first carbonation stage passed through a turbulating device to increase the absorption of the carbon dioxide into the liquid and then in a second stage are passed through means to further increase the carbon dioxide absorption.
24. A method according to Claim 23, characterised in that the carbon dioxide flow and the liquid flow are controlled by a flow sensor (16, 46).
25. A method according to Claim 23 or 24, characterised in that the liquid is a pre-mix beverage and is supplied from a bag-in-box container.
26. A method according to Claim 23, 24 or 25, characterised in that the carbonated liquid is passed around a continuous loop (20) and is dispensed via a branch line (19) from the loop (20).

27. A method according to any one of Claims 23 to 26, characterised in that at least 80% of total carbonation is achieved in the first stage.

28. A method according to any one of Claims 23 to 27, characterised in that the first stage and the second stage are carried out at different pressures, the liquid inflow rate is fixed at a lower rate than the dispense rate and the carbon dioxide is allowed to flow in as required during the dispense.

29. A method according to Claim 28, characterised in that the liquid is trickled via a non-return valve into a continuous loop of the carbonated liquid until all the carbon dioxide has been dissolved and the liquid flow is switched off when a pre-set pressure is reached.

30. A method according to Claim 29, characterised in that the second stage pump is controlled to continue to operate for a short period after dispense has finished.

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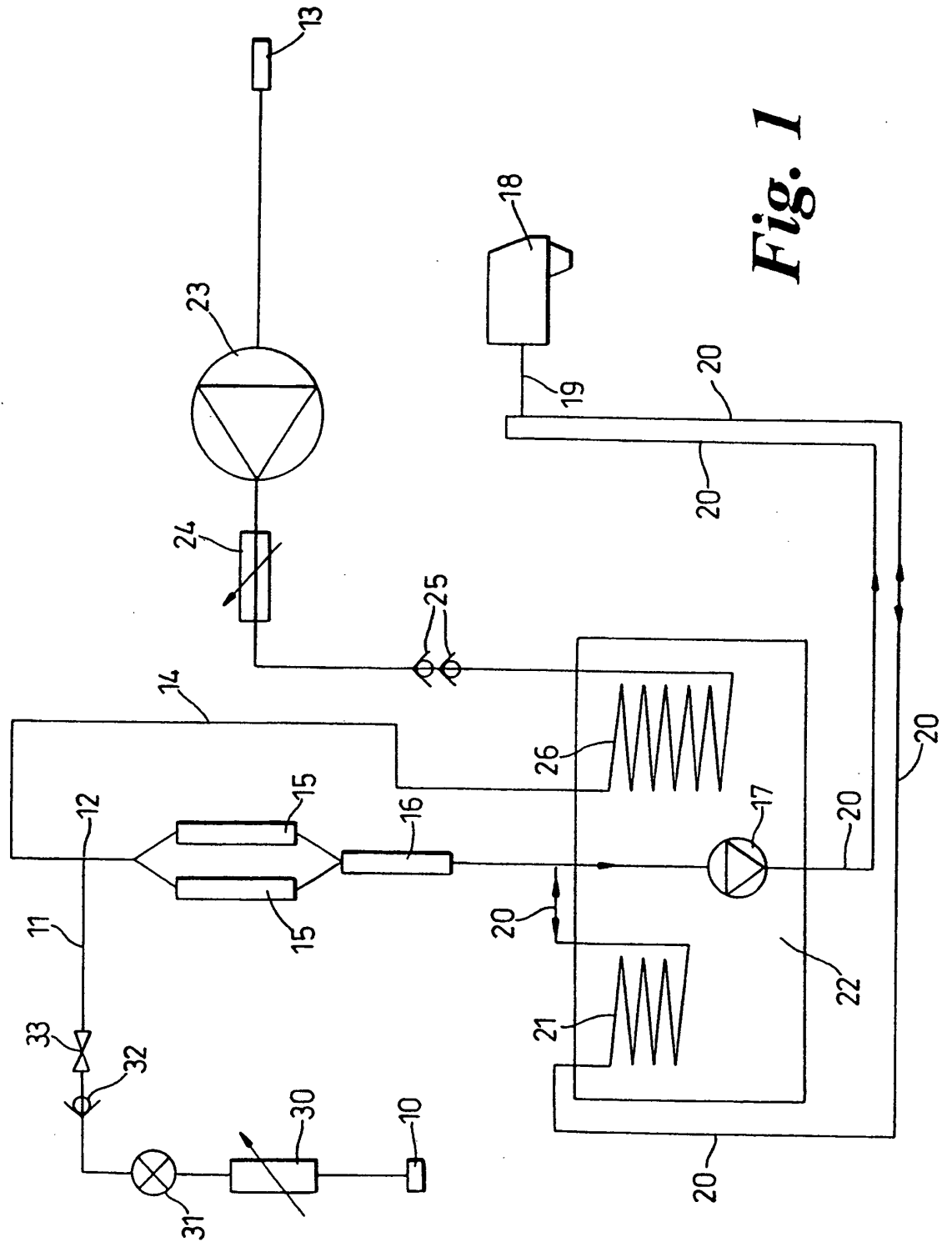
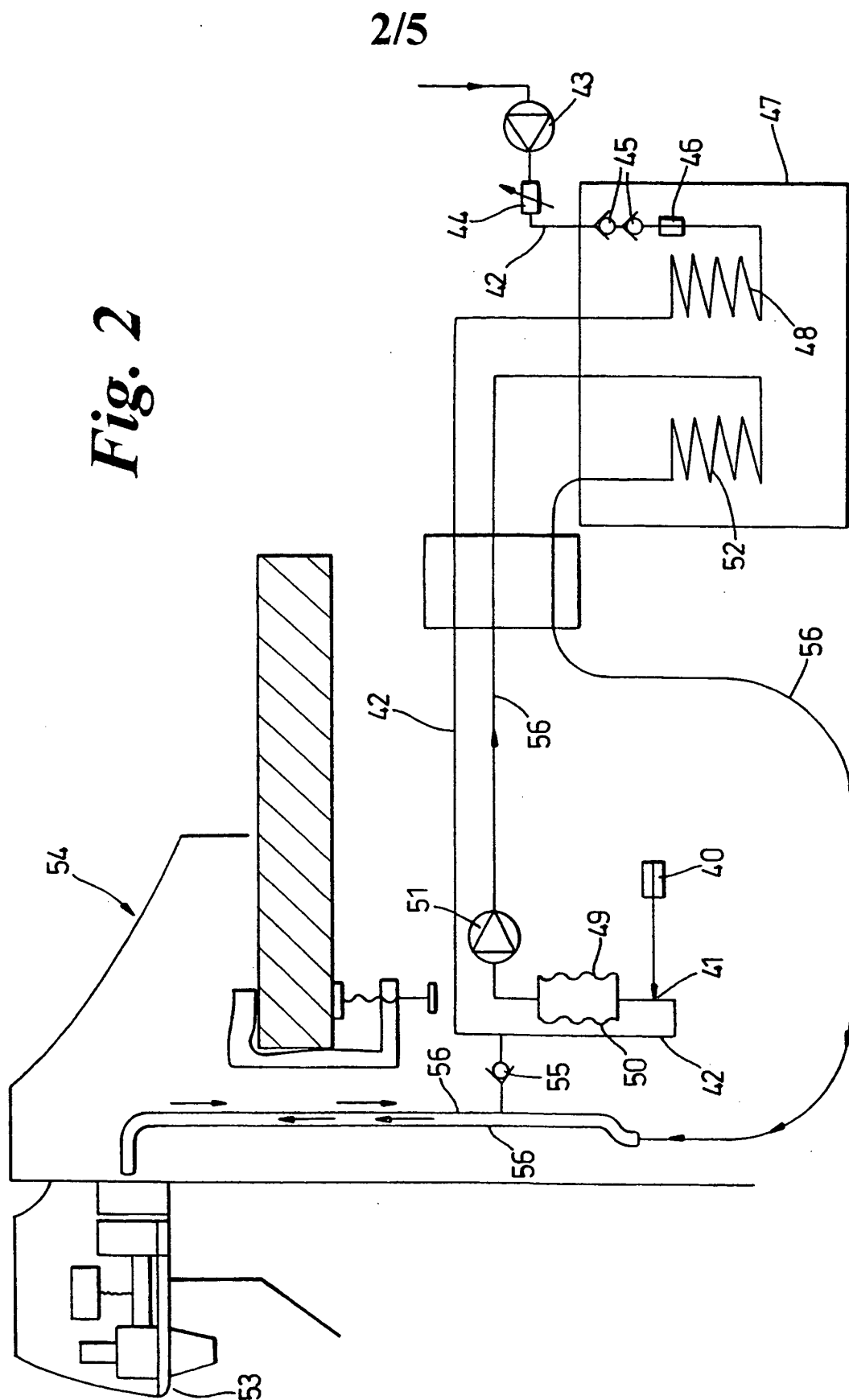


Fig. 1

Fig. 2

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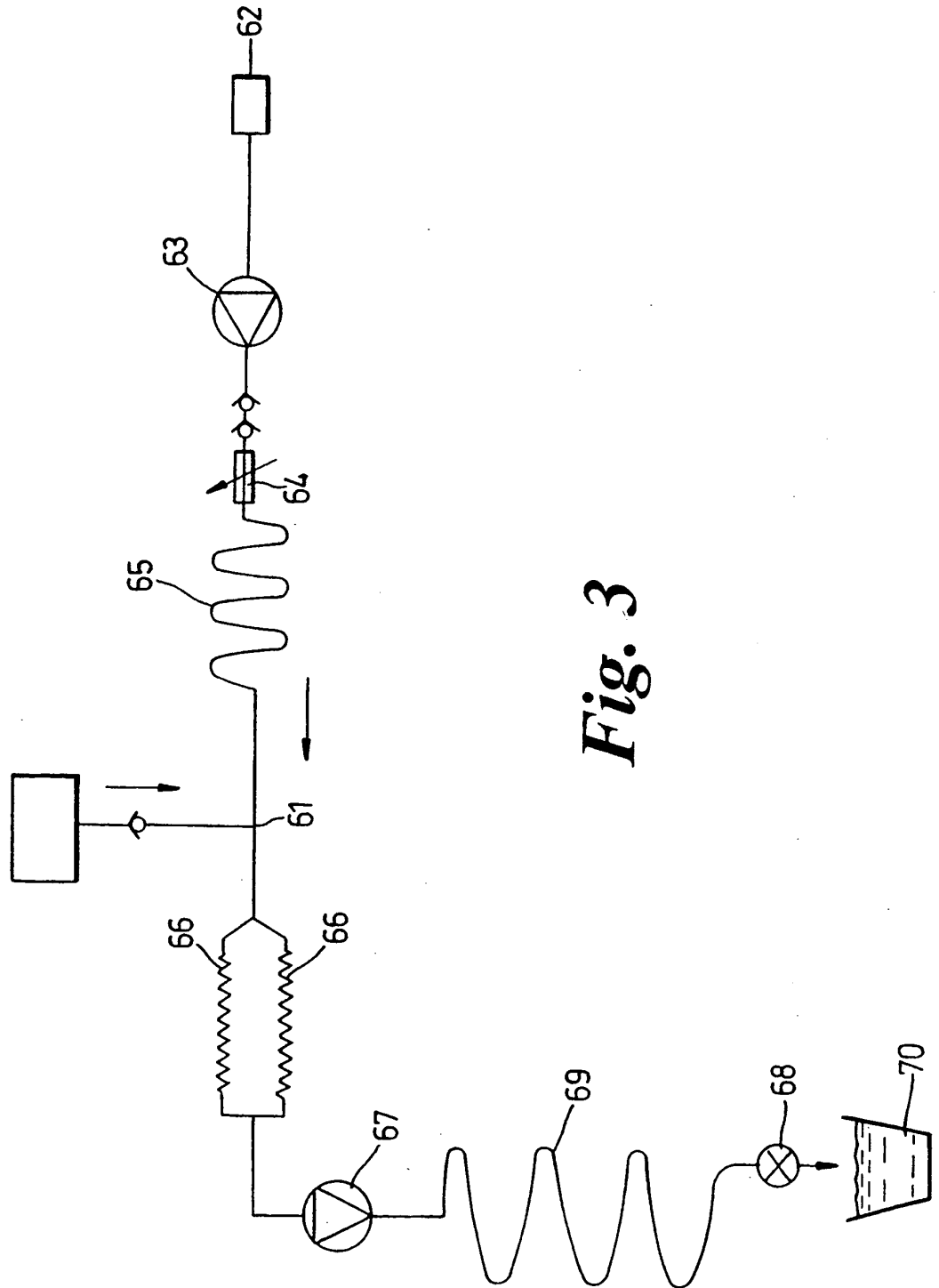


Fig. 3

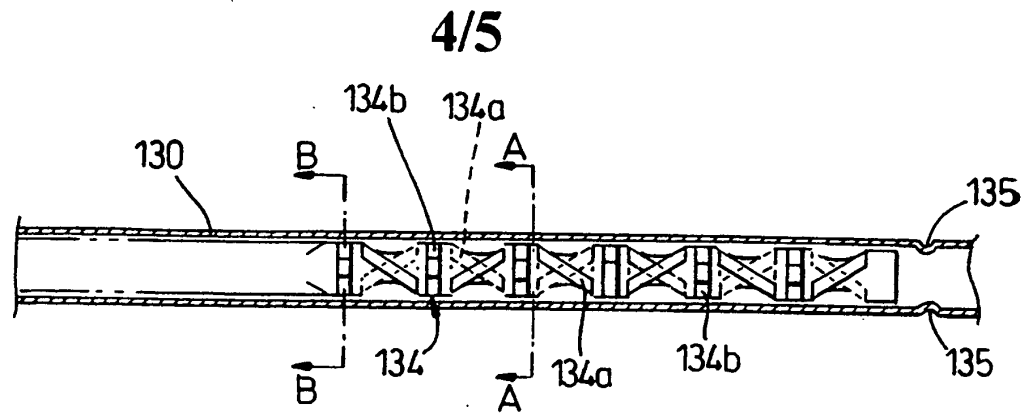


Fig. 4

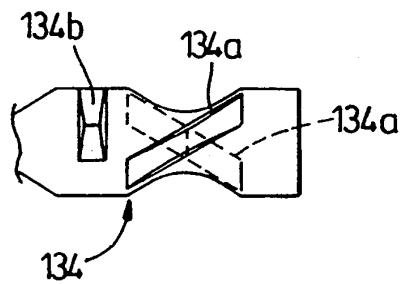


Fig. 5



Fig. 6

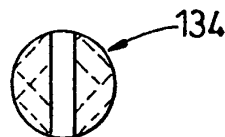


Fig. 7

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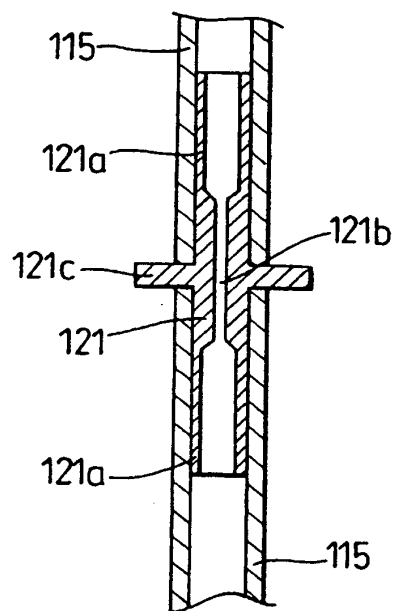


Fig. 8

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/03610

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B01F3/04 B01F5/06 B67D1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B01F B67D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	US 5 340 382 A (TH.L.BEARD) 23 August 1994 (1994-08-23) column 3, line 54-67; claims; figures	1-30
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Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
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